WHY DIETARY BIOCHEMISTRY?

READERS SUMMARY

1. Quick overview of carbohydrate metabolism

2. Quick overview of fat metabolism

3. Quick over view of protein metabolism

4. Are all exercises created equal?

5. What exercises optimize us for health and longevity?

The process of how food is turned into ATP is called cellular respiration. Foods are made from carbohydrates, proteins, and fats. This a quick overview of dietary biochemistry to show how our foods and mitochondria have to interact. Carbs have four stages of metabolism that allow them to be transformed into CO2, H2O, and ATP. Stage one is called glycolysis. It has either 10 or 11 steps. 10 if they occur in the cytoplasm, or 11 if they occur in the mitochondria. It begins with glucose of glycogen and ends with pyruvate under anaerobic conditions. It only allows for 2 ATP to be made form glucose and three if glycogen was the source. It also liberated 2 hydrogens in the form of NADH. Stage two carb metabolism has no name but it allows formation of Acetyl CoA from pyruvate. This occurs in the mitochondrial matrix without oxygen, but is an aerobic process. No ATP is made but two Hydrogen atoms (H) are released to make 2 NADH. Stage three of carbohydrate metabolism is the Krebs cycle. This has eight steps and occurs in the mitochondrial matrix. Again no oxygen is required but it is an aerobic process. The pass through allows 2 ATP to be made at four steps and 2 H atoms are removed at 4 steps. 3 of those H atoms are picked up by NAD and the fourth by FAD. Stage four of carbohydrate metabolism is known as electron chain transport that we spoke about in detail in the recent mitochondrial series added to the QUILT. This path occurs on the inner membrane of the mitochondria and consists of relaying electrons from the H atoms from one protein carrier to another and transporting the remaining hydrogen ions into the inner membrane space to create a voltage change across the membrane. This creates an electrical current. The electrical current is then used to fuel ATP production. For each H atom carried to the chain system by NAD, 3 ATP are formed. For each H carried by FAD, 2 ATP are formed. A total of 36 ATP are made if the fuel substrate is glucose and the muscle is skeletal. A total of 37 ATP is made if the fuel is glycogen and the muscle is skeletal. A total of 38 ATP are made if the fuel is glucose and it is cardiac muscle, and 39 ATP are made if the fuel is glycogen and the muscle is cardiac.

Now for the fats' discussion. Triglycerides (TG's) is stored in adipocytes or in muscle and are the major storage depot of all humans. TG's contain fatty acids and a glycerol backbone. Muscles can only use fatty acids (FFA) as a fuel. FFA's can only be used as a fuel source aerobically in the mitochondria. FFA must undergo beta oxidation, which involves the removal of hydrogen atoms and the removal of a pair of carbon atoms to form Acetyl CoA. Those Acetyl CoA then can enter the Krebs Cycle and electrons chains. The ATP produced from FFA depends wholly on the number of carbon pairs. For human fat the yield is 138 molecules of ATP per molecule of FFA. When Glucose supplies are inadequate (low carb) , Oxalo-acetate must be converted to glucose, Acetyl CoA is derived from FFA is turned into acetoacetic acid, beta-hydroxybutyric acid, and acetone. Acetone is the bad breath maker!

Amino Acids are primarily used in anabolic cellular processes in human cells. They build proteins. BCAA (branched Chain AA) can be used a primary fuel source if required by environment, but constitute 5-15{a7b724a0454d92c70890dedf5ec22a026af4df067c7b55aa6009b4d34d5da3c6} of the energy supply in the long term especially in those engaging in dynamic intense activity. All amino acids have amino groups (NH2) that must be removed before it can be used for fuel. It gets removed either by oxidative deamination or transamination (most common). Then the AA enters the Krebs cycle and electron transport at several locations. Ultimately all of the intermediates except Acetyl CoA are converted to pyruvate before being used for energy. 15 ATP are derived from each of the amino acid derivatives utilized as pyruvate and 12 ATP are produced from each derivative utilized as acetyl CoA.

Now that basics of dietary human biochemistry are covered, you might ask, why should I care? Fuel sources are prioritized based upon uses and needs. Humans have fat as primary fuel sources. Then we go to muscle glycogen, then liver glycogen stores and finally circulating glucose. We use energy based upon the current cellular environment (levee 1). This choice is complex but based upon the interaction the type, duration and intensity of exercise, and the muscle fiber types the patient currently has. The long term and short term nutritional status and fitness levels are also critical factors that need to be assessed in terms of dietary recommendations. I tend to assess these using my quantified self platform of testing.

In general, short duration, high intensity dynamic exercise is a special situation (HIIT). This exercise relies predominately on the ATP-PC and glycogen stored in the muscle fibers. This is the kind of exercise we want to strive for to be optimized. In aerobic activity there is higher sustained intensity. This requires the use of carbohydrates (glucose and glycogen) as fuel substrates. They key point here for humans is that the lower the intensity of the aerobics, the more important fats are as a fuel source. So severe aerobic exercises like marathons cause severe metabolic stress to the system. It uses all fuel sources and increases the flow of electrons through our electron chains to create more leakiness. Remember the more leakiness we see across the first complex the more aging and degenerative diseases we see. This point is made crystal clear in this February 2011 study that has got many endurance athletes rethinking the training methods they hold dogmatic. I know of at least 12 professional teams who have totally revamped their approaches after seeing this data evolve over the last few years.

For optimization, we should shoot for exercises that are hormetic and do not constantly cause leakiness at the mitochondria. What does that mean? It means that exercise should be a mild stressor to the cell that helps it improve function and doesn’t degrade our function. We should use mostly HIIT exercising to save our mitochondria and our stem cells. Carbs provide a rapid and large amount of electrons to the respiratory chains. This in turn allows more ROS generation in the mitochondria. This leads to more aging and degenerative diseases as we saw in the last few posts about mitochondria. This information is counter intuitive but the data is already mounting that our biochemistry is not suited for endurance work. We are better suited to HIIT work using fats to provide electrons to replenish our ATP. That way we can save our somatic stem cells and, more importantly, not have to replenish our mitochondria, or take them out by apoptosis every 5 days instead of every 3 weeks. The choice should be yours to make based upon our biochemistry and not what a trainer tells you based upon the opinion of their associations.

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